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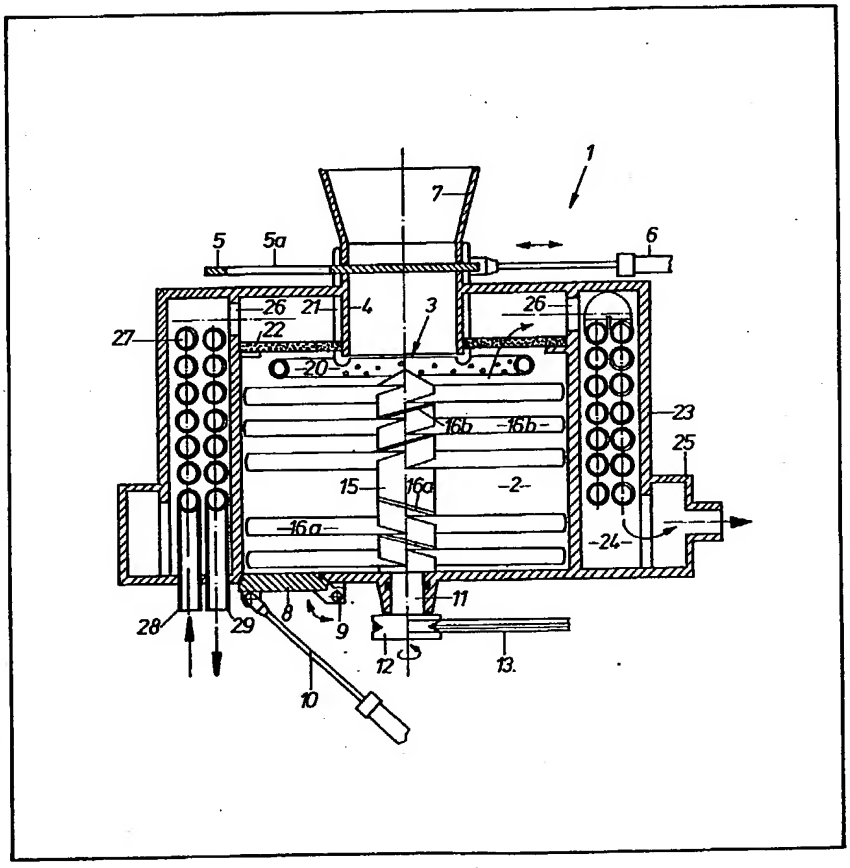
(54) **The cooling and mixing of moulding sand**

(57) Moulding sand can be properly cooled and mixed with components such as a binder by agitating it in a vacuum in the presence of water. The vapourization of the water cools the sand. This is useful where hot sand from a casting is to be recycled. Apparatus for this can comprise a filler port 3 leading to a mixing chamber 2. The chamber 2 contains an agitator 15 and a device for spraying water 20. An annular chamber 24 contains cooling coils 27 for condensing vapour removed from the sand in chamber 2 via ports 26.

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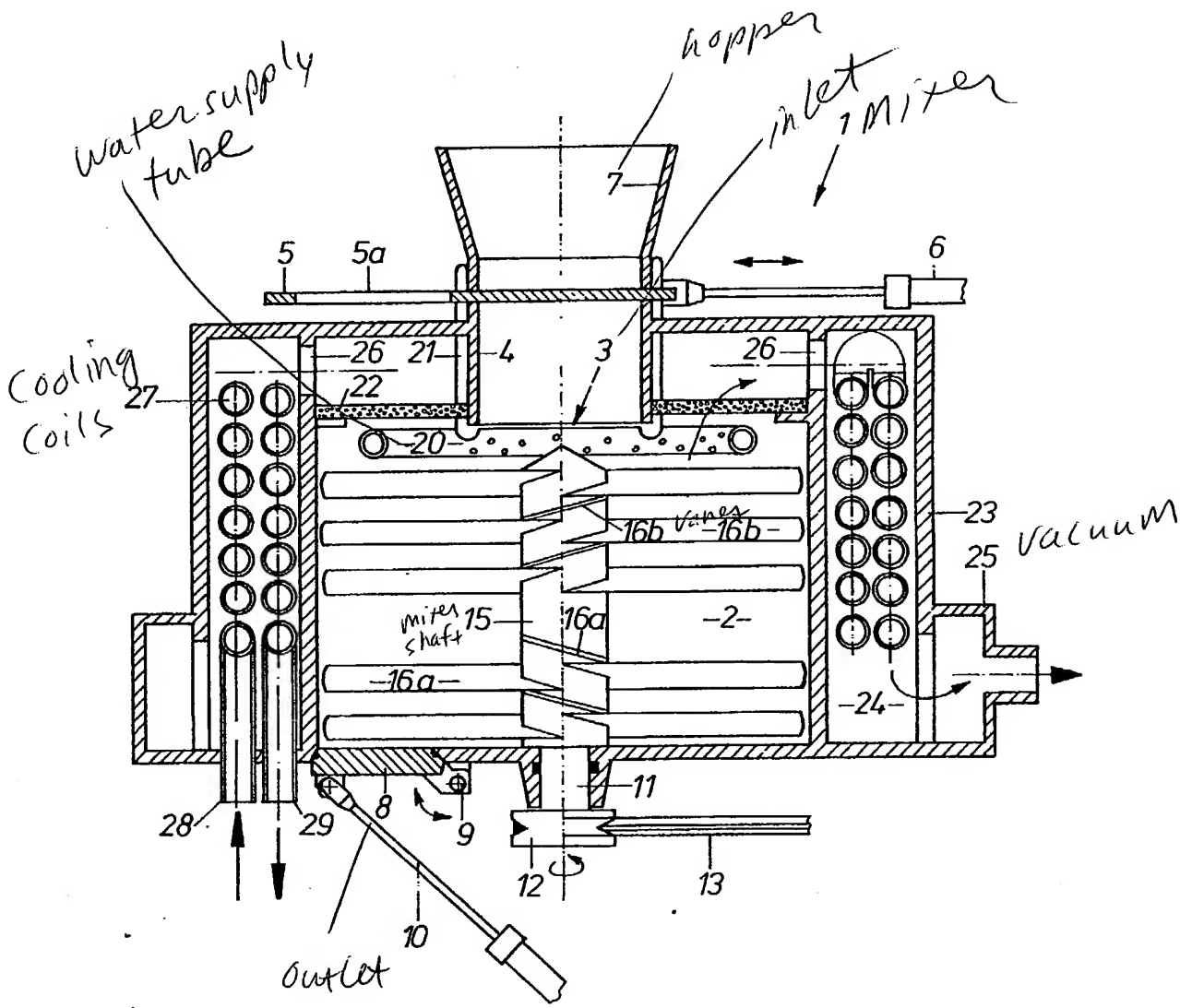
water supply tube
hopper
inlet
Mixer
7
5
5a
6
Cooling Coils
27
26
21
4
3
26
22
20
16b
vanes
16b
23
25
vacuum
mixer shaft
15
16a
2
16a
24
11
28
29
8
9
12
13
10
Outlet

SPECIFICATION

# The cooling and mixing of moulding sand

The invention relates to a method and to apparatus for the preparation, more particularly for cooling and mixing, of moulding sand. Sand, obtained from a sand batch is cooled, cleaned where appropriate, mixed with other substances by the addition of water, and homogenized by intensive agitation. This results in the sand particles becoming at least partially covered with a binding agent.

The purpose of preparing sand in the production of casting moulds is mainly for the following reasons: to establish a correct distribution of particle size, and a correct ratio of quartz sand, binder, coal dust as well as fresh and recycled sand; to homogenize the mixture while covering the particles substantially with binder; to adjust the correct moisture content; to remove unusable constituents, such as sand lumps, iron, dust; to adjust the correct sand temperature; and to convey the sand to its place of use. The proportion of recycled sand in the mixture can amount to 80% or more. Since the sand will be obtained from the sand batch at an elevated temperature, for example 100°C to 140°C, cooling is necessary before the sand is added to the mixing device. Cooling to a temperature between 35°C and 45°C is frequently regarded as adequate. As a rule, the sand is cooled by means of moisture, and large quantities of air blown through the sand, so that the latent heat of vapourization can be utilized for cooling purposes. The quantity of air required to do this is exceptionally large. A processing plant which can process approximately 80 tons of sand per hour requires air at the rate of several hundred thousand cubic metres per hour, and an energy input of up to 160 kWh or more. Such an apparatus required for cooling the sand occupies a correspondingly large amount of space.

The cooled sand is then transferred, together with other substances, more particularly fresh sand and binder, into a mixing device, such as a batch mixer. Mixing and homogenizing can be performed by means of pug mills with rotating kneading rolls which perform a kneading action on the sand in addition to a mixing action. However, it is more common to employ mixing devices, each with a mixing vessel containing at its bottom a rotating agitating vane which conveys the material continuously radially outwardly and obliquely upwardly, and additionally containing two or more rotating agitating units which extend to a position close above the top edge of the agitating vanes. These rotating units can take up and intensively agitate the sand and the other constituents. The object of this agitation is to homogenize the charge within the shortest possible time, for example 90 seconds, and to cover the surface of the individual sand granules with a binder.

Accurate investigations have shown that complete covering is not achieved. The binder, usually containing clay, takes the form of minute dough-like platelets, which impinge only partially on the surface of the sand granules, and therefore cover them only partially.

Agitating spiders, extending directly to the agitating vanes which rotate on the bottom and are driven at speeds of 1500 rev/min or more, are used to agitate the charge.

W have now devised a method of mixing in which cooling and mixing can be rendered less energy consuming and less time consuming. The sand and the binder are mixed in a vacuum, i.e. in a mixing zone whose pressure is substantially reduced compared with that of the ambient atmosphere.

Thus the present invention consists in a method of preparing sand for moulding which comprises: the step of mixing under vacuum in the presence of water, sand particles and a binder, thus covering at least partially the particles with binder and cooling the particles by means of latent heat of vapourization of the water.

The invention also consists in a method of recycling sand in a casting process, in which used sand is prepared for subsequent casting by the method of preparation of the invention.

The invention further consists in an apparatus suitable for preparing sand, comprising: a sealable mixing zone containing an agitator; means for supplying water to the mixing zone; a vacuum chamber and means for operating the vacuum; the vacuum chamber being in communication via a valve with the mixing chamber.

Advantageously, sand and water are introduced into a mixing zone, which is sealed with respect to the ambient atmosphere, are agitated and a vacuum is produced in the mixing zone and gases and vapours are discharged therefrom.

This method of operation can offer substantial advantages. To begin with, the use of this particular method results in moulding sand having substantially less resilience during moulding, which leads to a higher accuracy of form and facilitates stripping. This is thought to be due to the fact that in known methods not only sand, binders and other additives are homogenized with each other in the mixing zone, but air is also mixed. Especially in cases of intensive agitation, air in the mixing zone reaches high velocities, which can impair to a certain extent direct contact between the binder platelets and the surface of the sand granules. In particular, there is a risk of minute quantities of air being trapped between the surface of the sand granules and the binder platelets, and such air cannot be forced out even by the high pressures which are used during moulding. Adhesion of a binder film on the surface of the sand granules and adhesion between sand granules are both therefore impaired. The minute, enclosed quantities of air also increase the elasticity of press-formed sand mouldings.

Another advantage of the novel method is that a substantial part of the cooling operation can be performed during the mixing itself. This is due to the fact that moisture contained in the sand or introduced therein not only evaporates due to the temperature of the system, but is further vapourized by evacuation of the mixing zone. This results in more heat being taken up and dissipated from the sand. By cooling the sand within the mixing zone it is possible either to dispense entirely with conventional sand

cooling devices, or to make them substantially smaller, for example in the form of a pre-cooling device. Moreover, since dissipation of the heat by the novel method is performed with the aid of vapour within an enclosed system, namely the evacuating system, it is possible, by a simple procedure, to recover heat abstracted from the quantity of sand in a useful manner. To this end it is advantageous if the vapours, which are removed from the mixing zone, are cooled and condensed against condensation surfaces while the vacuum is maintained.

It is essential that the vacuum in the mixing zone is adjusted to a value which ensures that the moisture introduced into the sand at the residual pressure and temperature is subjected to the further vapourization mentioned above. A pressure of less than 17 Torr, more particularly approximately 10 Torr, has been found convenient.

Cooling and condensation of the almost gas-free vapour atmosphere is conveniently performed by means of the heat absorbing part of a heat pump, which transfers recovered heat to a heat-using circuit.

In a practical embodiment it has been found convenient if recycled or other sand is introduced into the mixing zone at a temperature between 50 and 90°C, more particularly between 55 and 80°C. Given a charge of, for example, 2 tons, the temperature of the sand can be reduced to a value between 30° and 40°C over a mixing time between 60 and 180 seconds.

In some cases it has been found convenient if the mixture is first agitated after the mixing vessel is filled, an then the mixing vessel is evacuated whereupon, after a pre-determined mixing time of for example 30 seconds, water is introduced into the agitated mixture, more particularly by spraying or mist spraying. In some cases it can also be convenient initially to agitate the recycled portion of the sand with water, to evacuate the mixing zone, and to add the binder only after a defined mixing time has elapsed.

In order to increase the cooling action, accompanied by a further saving of energy and space, it is convenient if one or more precooling zones precede the mixing zone. Each precooling zone can also be charged in batches. For this it is convenient if the cooling zones are also constructed as zones sealed with respect to the exterior atmosphere, so that the quantity of heat, which is to be dissipated by means of the added moisture, can be recovered by condensing the moisture on cooling surfaces, for example by means of a heat pump. Cooling can thus be effected by utilizing the latent heat of vapourization. Conveniently, however, cooling in this case is also effected by vapourization of the moisture, mainly by evacuating the precooling zone while sand and water are agitated. The resulting vapours are then discharged and condensed on condenser surfaces while the process of evacuation takes place.

In one embodiment, two precooling zones have been found convenient: sand at a temperature of 120°C is cooled in a first precooling zone to approximately 80°C, and is then further cooled in a second precooling zone from approximately 80°C to approximately 55°C.

Advantageously, each of the mixing or precooling vessel together with its associated device is completely enclosed in a casing forming a vacuum chamber, with the exception of the inlets and outlets which are hermetically sealed with respect to the exterior. Conveniently, the vessel is provided with a plurality of large openings distributed in the circumferential direction of the annular vacuum chamber, and these apertures can be opened and closed in a controlled manner by valves. The interior of each vessel may also be provided with at least one spraying or mist spraying head for supplying water. The associated valves, the devices for agitation and the drives can all be disposed within the outer casing, i.e. in the vacuum. The outer casing has a volume sufficiently large that one can generate within the interior of the vessel a vacuum which is adequate to evaporate the moisture within the desired time when the connecting apertures are opened. Conveniently, the cooled condensing surfaces for precipitating the moisture are also disposed within the casing. The associated cooling device, more particularly a heat pump, can be disposed outside the casing. The vacuum attained within the vacuum chamber can be adjusted by an attached vacuum device during the time of charging and discharging the vessel. In this case it is unimportant if sand particles are swept along by the resultant flow when the connecting ports between the vacuum chamber and the mixing zone are opened – the particles simply come to rest in the vacuum chamber, are deposited at its bottom and can be readily discharged by means of a sluice. It is also possible to prevent passage of sand from the mixing chamber to the vacuum chamber, by means of filters or chicanes.

The supply of moisture can be controlled substantially more accurately than hitherto by mist spraying, or by spraying water into that agitated sand bed in the mixing zone or precooling zone. Moreover, direct mist spraying into the agitated sand bed allows a far more rapid contact with the large total surface area of the sand granules, permits the absorption of heat and allows the moisture to evaporate immediately thereafter. It is merely important to ensure that the water is introduced in droplet form so that evaporation of the water prior to contact with the sand surface is suppressed as far as possible.

If the used sand is not precooled in a vacuum, the air which absorbs the moisture is maintained in circulation in a closed circuit. In this case the cooling and condensing surfaces of a cooling device (for example a heat pump) are disposed in this air circulating circuit.

This not merely assists and improves covering of the sand granules with a binder but a very compact construction can thus be combined with a substantial saving of energy.

The precooling and mixing zone can also be disposed in the same vacuum casing, so that the cooling and condensing surfaces disposed therein serve to condense the moisture from both zones.

It is also possible to combine pressure sluices with the charging and discharging ports of the precooling and mixing vessels so that the interior of the vessel

can remain constantly under vacuum.

In this case, the vacuum chamber can be in constant free flow communication with the interior of the vessel.

The term "vacuum" in this context refers to an air pressure which is distinctly lower than the ambient air pressure, and is not limited to an atmosphere which is also free of all vapour.

The accompanying drawing shows, by way of example, a vertical section through an apparatus according to the invention.

The apparatus 1 comprises a mixing chamber, having a filler port 3 in its upper region, namely at the bottom end of a filler duct 4 which is associated with a valve 5 and aperture 5a which can be actuated by means of a thrust jack 6. In the illustration, the valve is shown in the closed position. Above the valve, the charging duct 4 flares in the form of a charging hopper 7.

The mixing chamber 2 is closed at the bottom but has a bottom aperture through which the contents can be discharged. The bottom aperture is associated with a closure 8, which is pivotably supported at 9 and can be moved into the closed or open position by the actuating means 10.

In the centre of the mixing chamber 2 there is supported a mixer shaft 15 with a trunnion 11, extending outwardly through a bottom hub and supporting a belt pulley 12 with a driving belt 13. The mixer shaft is provided with mixer tools. The particular function of such tools is to maintain the material charged into the chamber 2 in constant turbulent agitation in order constantly to expose the largest possible surface area of the material particles and at the same time to act powerfully on the material.

To this end, vanes 16a, 16b are disposed on the shaft 15 and are subdivided into two vane groups in which the vane blades have opposite pitch. The arrangement is such that the bottom set of vanes 16a takes up the material from the region of the bottom and throws it towards the top while the top set of vanes 16b collects the thrown material and accelerates it both in the circumferential direction as well as into the opposite downward direction. This results in intensive agitation of the material within the mixing chamber 2.

A device, which concentrically surrounds the charging aperture 3 and is intended to supply moisture in the form of vapour or water or to supply other liquid additives, is arranged above the mixer shaft 15. An annular tube 20 with a plurality of small exit ports is provided for this purpose, and the annular tube can be connected by means of pipelines 21 to a corresponding moisture source, via, where appropriate, controllable valves.

The mixing chamber 2 is closed at the top by a filter plate, for example, a sintered metal plate 22 which retains some of the particles in the chamber 2 but allows vapour and air to pass through substantially without obstruction. Where required, the sintered plate can be provided with a pneumatic or mechanical cleaning device. Cleaning of the sintered plate at intervals in time can be performed, for example by means of a compressed air surge which is oriented towards the chamber 2.

The mixing chamber 2 is surrounded by a concentric annular chamber 24, closed on its outside by means of a casing 23. The annular chamber 24 communicates with the mixing chamber 2 by means of ports 26 and is in flow communication with the head room which is provided above the sintered plate 22. A connecting socket for connecting the annular chamber 24 to a source of low pressure or vacuum is provided at 25.

Cooling coils 27 are arranged within the annular chamber 24, for example on the heat absorbing side of a heat pump. The cooling coils are connected via outwardly extending sockets 28, 29 to the coolant circuit of a cooling device, more particularly of a heat pump. A discharging device, not shown, disposed at the bottom of the annular chamber 24 permits liquid accumulated in the annular chamber 24 to be sluiced out, or otherwise discharged.

In operation, the mixing chamber 2 is filled with a hot material mixture through the filling hopper 7, with the valve 5 open. Thereafter, the valve 5 is closed, at least substantially hermetically. The materials in the chamber 2 can then initially be mixed with each other, substantially in their dry state. After the mixing chamber 2 is hermetically closed, it is advantageously evacuated by connection to the annular chamber 24, so that air is substantially withdrawn from the mixing chamber 2 and removed more or less suddenly from the material in the chamber. Dry mixing of the material takes place in a vacuum so that any binder can bear in the form of a shell or film uniformly and without interference on the exposed sand granule surfaces.

When the desired degree of mixing has been obtained (or alternatively at the commencement of mixing), the required quantity of moisture is supplied to the sand through the annular distributor 20. Moistening is performed exceptionally rapidly and uniformly because the moisture is applied through nozzles into the agitated sand mass. Vapour produced by impact with the sand granules is continuously and rapidly discharged from the mixing chamber 2 and encounters the cooling coils 27. The vapour is condensed within the vacuum, which also prevails in the annular chamber 24, and the resulting liquid is collected at the bottom of the annular chamber 24. In this way, the material is rapidly and reliably cooled to the required temperature.

CLAIMS

1. A method of preparing sand for moulding which comprises: the step of mixing under vacuum in the presence of water, sand particles and a binder, thus covering at least partially the particles with binder and cooling the particles by means of latent heat of vapourization of the water.

2. A method according to claim 1, in which mixing is carried out by agitation resulting in an homogeneous product.

3. A method according to claim 1 or claim 2, in which sand is introduced into a mixing zone, then the pressure in the zone is lowered, then water is introduced into the zone thus cooling the sand.

4. A method according to any one of the preceding claims in which sand and binder are mixed in a mixing zone before the addition of water.

5. A method according to claim 3 or claim 4, in which water is introduced to the mixing zone by mist or other spraying.

6. A method according to any one of the preceding claims, in which mixing is carried out in a mixing zone sealable with respect to the external atmosphere, and during mixing gas and/or vapour produced is removed from the zone.

7. A method according to claim 6, in which vapour removed from the mixing zone is condensed.

8. A method according to claim 7, in which the vapour is condensed in a vaccum.

9. A method of recycling sand in a casting process, in which used sand is prepared for subsequent casting by a method according to any one of the preceding claims.

10. A method of recycling sand according to claim 9, in which used sand is introduced into a mixing zone at an elevated temperature resulting from the preceding casting.

11. A method of recycling sand according to claim 9 or claim 10, in which used sand is cooled in a pre-cooling zone to a temperature from 50-90°C by agitation with water, and by removal of gas and/or vapour, before being introduced into a mixing zone.

12. A method of recycling sand according to claim 11, in which the pre-cooling zone is sealable with respect to the external atmosphere, and the gas and/or vapour is removed by enclosed flow from the pre-cooling zone and is condensed in a condensing zone.

13. A method of recycling sand according to claim 12, in which the pre-cooling zone and condensing zone are evacuated while the sand and water is mixed in the mixing zone.

14. A method of recycling sand according to any one of claims 9-13, in which the sand is cooled to a temperature from 20-40°C during the mixing stage.

15. A method of preparing sand, or a method of recycling sand, substantially as herein described with reference to the accompanying drawing.

16. An apparatus suitable for performing a method according to any one of claims 1-7, comprising: a sealable mixing zone containing an agitator; means for supplying water to the mixing zone; a vacuum chamber and means for operating the vacuum; the vacuum chamber being in communication via a valve with the mixing zone.

17. An apparatus according to claim 16, additionally comprising at least one pre-cooling zone.

18. An apparatus according to claim 16 or claim 17, additionally comprising means for supplying solid material to the mixing zone, and means for discharging mixed product.

19. An apparatus according to any one of claims 16, 17 and 18, in which the mixing zone and associated devices are disposed substantially completely within the vacuum chamber, with the exception of hermetically closable charging and discharging ports.

20. An apparatus according to any one of claims 16-19, in which a condenser or other condensing device is disposed in the vacuum chamber, the condensing device being connected to the cooled side of a heat pump.

21. An apparatus according to any one of claims 16 to 20, in which the means for supplying water comprises at least one spray head which is disposed within the mixing zone.

22. An apparatus according to any one of claims 16-21, in which the device for supplying sand can be charged with sand derived from a preceding casting.

23. An apparatus according to claim 22, in which the device for supplying the used sand can be charged from a precooling device.

24. An apparatus according to claim 23, in which the precooling device comprises a precooling vessel, which is sealable with respect to the external atmosphere and can receive the used sand hot from a preceding casting operation, an agitating device, means for supplying water, and a closed device for extracting hot and moist gas and/or vapour.

25. An apparatus according to claim 24, in which the means for supplying water is a mist sprayer.

26. An apparatus according to claim 24 or claim 25, in which the extraction device comprises a suction blower which is connected to the precooling vessel in a closed gas circuit containing a cooling and condensing device.

27. An apparatus according to claim 24 or 25, in which the extraction device comprises a vacuum chamber which is provided with a vacuum device and contains a cooling and condensing device as well as a suction port which extends to the precooling vessel and can be closed by a closing means.

28. An apparatus according to claim 27, in which the closing means is a valve.

29. An apparatus according to claim 16, substantially as herein described with reference to the accompanying drawing.

30. Method and apparatus for the preparation, more particularly for the cooling and mixing of moulding sand, in which said method and apparatus the used sand, obtained from the sand batch is cooled, is cleaned where appropriate, and is mixed with other substances by the addition of water and is homogenized accompanied by intensive agitation and the sand particle surface is at least partially covered with a binding agent, characterised in that the sand granule surface is covered with binder under vacuum.

31. Apparatus for performing the method according to any or several of the claims 1 to 7 with at least one cooling station and one mixing station in which the said mixing zone is associated with a vessel for receiving and with apparatus for supplying the constituents to be mixed, with an agitating device and a device for supplying water and a device for removing the finished mixture, characterised in that the vessel can be hermetically sealed or is disposed in a hermetically sealable casing, that a vacuum chamber, provided with apparatus for generating a vacuum and at least one flow connection, which can be closed by a controllable valve device, is provided between the vessel and the vacuum chamber.

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